

FIBER OPTICS



AMERICAN OPTICAL COMPANY

SPACE DEFENSE DIVISION • SOUTHBRIDGE, MASSACHUSETTS

IMAGE CONDUIT

AO Image Conduit consists of thousands of clad fibers fused together to form a rigid bundle or rod which is capable of transmitting an image from one end to the other. Image Conduit can be bent into complex shapes simply by heating it over a Bunsen burner or similar torch and manipulating it as one would a glass rod. In this procedure the Conduit should be rotated and oscillated in the flame so as to heat it gradually and uniformly until it responds to pressure. Due to the small diameter of the individual fibers Image Conduit can be bent to angles with very small radii with minimum loss in transmission. Image Conduit is supplied with ground and polished ends.

In addition to the stock sizes listed below we can supply Image Conduit in any length up to 4 feet. Quotations on custom lengths and cross sections will be forwarded on receipt of information on dimensions, tolerances and quantities.



CAT. NO.	CROSS SECTION (inches)	FIBER SIZE (microns)	NO. OF FIBERS	RESOLUTION LINE PRS/MM	LENGTH (inches)
IC-1-6	1/8 hex.	12	73,000	40	6
IC-1-12	1/8 hex.	12	73,000	40	12
IC-2-6	1/4 hex.	25	73,000	20	6
IC-2-12	1/4 hex.	25	73,000	20	12
IC-100-6	1/8 round	12	70,000	40	6
IC-100-12	1/8 round	12	70,000	40	12

NOTE: IC-100 Image Conduit is "ruggedized" for increased mechanical strength.

CLAD ROD

AO Clad Rods provide an extremely efficient means for transmitting light over a fixed path. They consist of a highly transparent core glass coated with a cladding glass of lower refractive index. The acceptance angle for Clad Rods is 60° included. The standard core-cladding area ratio is approximately 80%-20%. Clad Rod is supplied with ground and polished ends.

Clad Rods can be bent to curved paths by the procedure outlined for Image Conduit. For maximum efficiency, Clad Rods should not be bent to a radius less than 20 times the diameter of the rod. If a shorter radius configuration is required Image

Conduit should be used in place of Clad Rod.

Custom Clad Rod of other diameters, lengths and numerical apertures can be supplied. Quotations on custom Clad Rod will be forwarded on receipt of information on dimensions, tolerances and quantities.

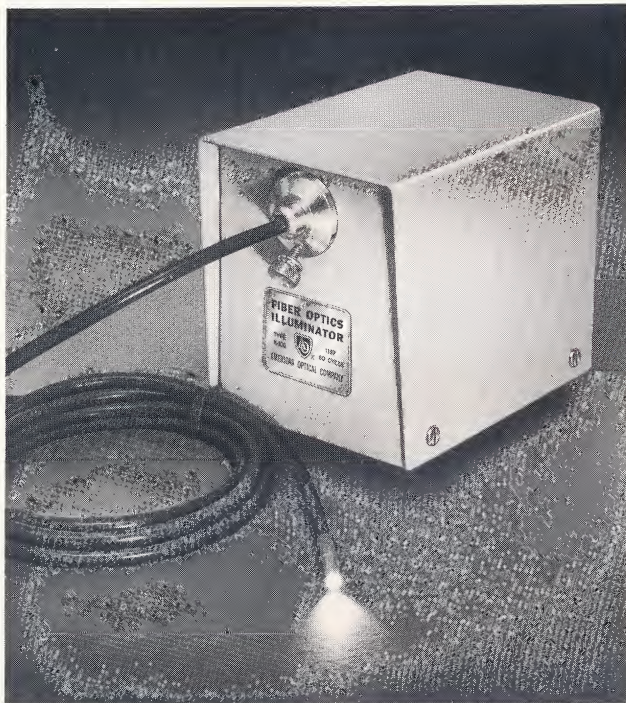
CATALOG NO.	DIAMETER (inches)	LENGTH (inches)
CR-05-6	1/16	6
CR-05-12	1/16	12
CR-1-6	1/8	6
CR-1-12	1/8	12
CR-2-6	1/4	6
CR-2-12	1/4	12



AO ILLUMINATORS FOR FIBER OPTICS

These illuminators have been especially designed for use with AO Fiber Optic Light Guides. They provide a convenient and inexpensive source of intense illumination for

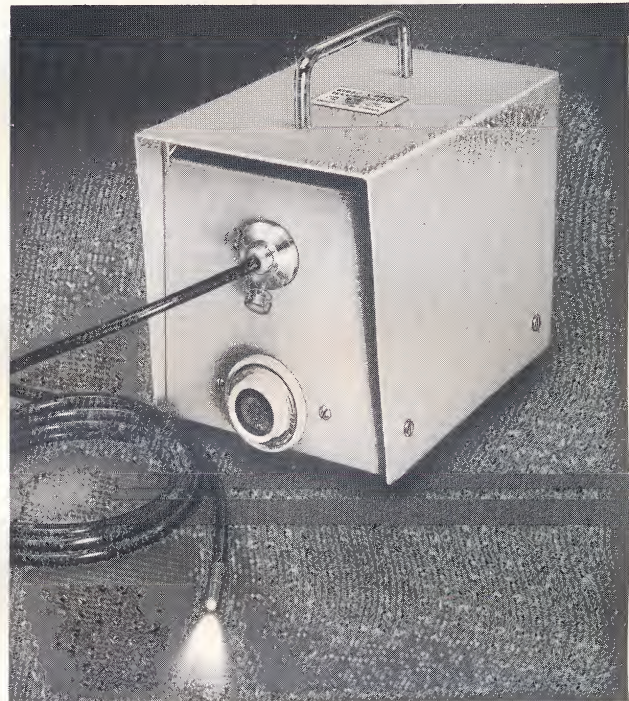
a variety of fiber optic applications. Adapters are available for coupling all standard AO Light Guides to these illuminators.



K-100 ILLUMINATOR

The K-100 Illuminator is designed for applications requiring a low-voltage source for $\frac{1}{16}$ and $\frac{1}{8}$ inch diameter Light Guides. A pre-focused lamp and a special condensing system provide an intense cone of illumination of 60° included angle. A two-way switch permits operation of 6.2 volts or 6.8 volts. Normal lamp life at 6.2 volts is 150 hours and at 6.8 volts, 60 hours. For 110-120 volt, 60 cycle AC.

CAT. NO.	COLOR	HEIGHT	WIDTH	LENGTH	WEIGHT
K-100	Green	4½"	4"	5½"	5 lbs.



K-150 ILLUMINATOR

The K-150 Illuminator provides intense illumination for Light Guides up to $\frac{3}{8}$ inch in diameter. The light source is a 150 watt reflector projection lamp. The light intensity is continuously variable by means of a potentiometer. An efficient fan provides for cool operation. Rated lamp life at full voltage is 15 hours, for 110-120 volt, 60 cycle AC.

CAT. NO.	COLOR	HEIGHT	WIDTH	WEIGHT
K-150	Green	6"	6"	10 lbs.

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FLEXIBLE LIGHT GUIDES

AO Flexible Light Guides provide a highly efficient means for transmitting light over a flexible path. Examples of applications for which AO Light Guides are being used include: remote illumination, data processing, error sensing, scanning systems, fire detection, control systems and automatic programming.

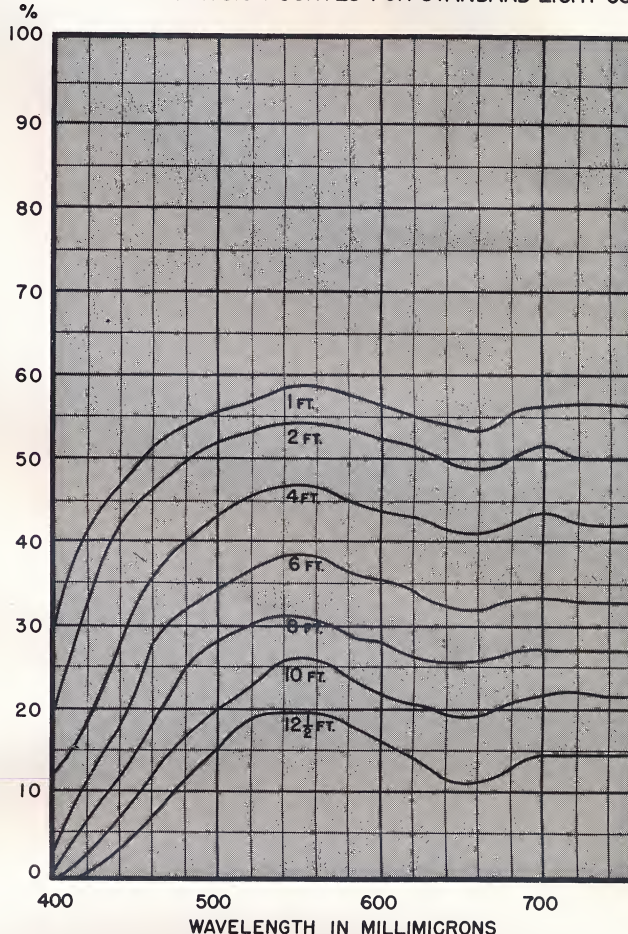
AO Light Guides consist of bundles of optical fibers cemented at each end in a closely packed array and free to flex in between. Standard Light Guides are fitted with either plastic or stainless steel end tips and are encased in a PVC plastic

CUSTOM LIGHT GUIDES

Custom Light Guides can be supplied with custom end tip hardware, sheathings and dimensions to meet your special requirements. They can be supplied with input and output faces of different cross sectional configuration. Typical configurations include: round-to-square; round-to-rectangle; round-to-slit, etc. Various forms of "branched" Light

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TYPICAL TRANSMISSION CURVES FOR STANDARD LIGHT GUIDES



sheath. The standard fiber diameter is 75 microns (.003 inch) and the acceptance angle is 60° included. The end loss factor due to Fresnel reflection and the effective core area ratio (packing fraction) is approximately 30% and the line loss factor (attenuation with length) is approximately 10% per foot.

AO Light Guides transmit light through the visible and near infrared spectrum out to a wave-length of about 1.5 microns. The above graph shows typical transmission characteristics of the LG and LGM series of Light Guides.

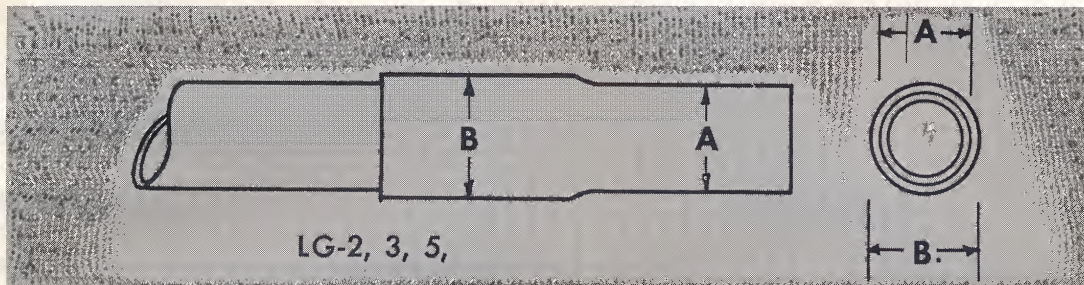
Guides can also be supplied. Such devices can be used to provide a multiplicity of outputs from a single source or to bring light from multiple sources to a single detector.

We will be pleased to quote on Light Guides upon receipt of a drawing.



LG SERIES FLEXIBLE FIBER OPTIC LIGHT GUIDES

(Non-Metallic)



The LG series of flexible Light Guides are constructed of glass clad optical fibers sheathed in PVC plastic tubing. The ends are epoxy-potted in plastic end fittings and are optically ground and

polished. The plastic end fittings are provided for applications requiring non-metallic construction. The LG series is available from stock in diameters and lengths listed below.

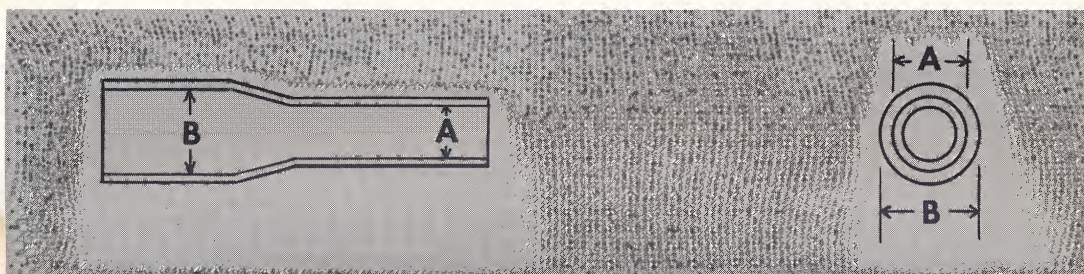
Cat. No.	Nominal Fiber Bundle Size	Approx. No. of Fibers	Minimum Radius of Bend	A $\pm \frac{1}{64}$	Dia. A Max. Eccentricity	B Max.	Length
LG-2-12	$\frac{1}{16}$	500	$\frac{3}{8}$	$\frac{1}{32}$	$\frac{1}{32}$	$\frac{1}{16}$	12
LG-2-24							24
LG-2-36							36
LG-2-48							48
LG-2-60							60
LG-2-72							72
LG-3-12	$\frac{1}{8}$	1500	$\frac{1}{4}$	$\frac{1}{32}$	$\frac{1}{32}$	$\frac{1}{16}$	12
LG-3-24							24
LG-3-36							36

(All dimensions in inches)

Cat. No.	Nominal Fiber Bundle Size	Approx. No. of Fibers	Minimum Radius of Bend	A $\pm \frac{1}{64}$	Dia. A Max. Eccentricity	B Max.	Length
LG-3-48	$\frac{1}{8}$	1500	$\frac{1}{4}$	$\frac{1}{32}$	$\frac{1}{32}$	$\frac{1}{16}$	48
LG-3-60							60
LG-3-72							72
LG-5-12	$\frac{1}{4}$	6000	$1\frac{1}{2}$	$\frac{1}{64}$	$\frac{1}{32}$	$\frac{1}{16}$	12
LG-5-24							24
LG-5-36							36
LG-5-48							48
LG-5-60							60
LG-5-72							72

LGM SERIES FLEXIBLE FIBER OPTIC LIGHT GUIDES

(Metal End Fittings)



The LGM series of flexible Light Guides are constructed of glass clad optical fibers sheathed in PVC plastic tubing and are similar to the LG series except that the ends are epoxy-potted in stainless steel end

fittings. The metal end fittings are designed for applications requiring closer mechanical tolerances than can be supplied with our LG series Light Guides.

Cat. No.	Nominal Fiber Bundle Size	Approx. No. of Fibers	Minimum Radius of Bend	A $\pm .003$	B $\pm .004$	Length
LGM-1-12	.020	30	$\frac{3}{8}$	.032		12
LGM-1-24						24
LGM-2-12	$\frac{1}{16}$	500	$\frac{3}{8}$	.109	.128	12
LGM-2-24						24
LGM-2-36						36
LGM-2-48						48
LGM-2-60						60
LGM-2-72						72
LGM-3-12	$\frac{1}{8}$	1500	$\frac{1}{4}$	.169	.220	12
LGM-3-24						24

(All dimensions in inches)

Cat. No.	Nominal Fiber Bundle Size	Approx. No. of Fibers	Minimum Radius of Bend	A $\pm .003$	B $\pm .004$	Length
LGM-3-36	$\frac{1}{8}$	1500	$\frac{1}{4}$	.169	.220	36
LGM-3-48						48
LGM-3-60						60
LGM-3-72						72
LGM-5-12	$\frac{1}{4}$	6000	$1\frac{1}{2}$	.245	.308	12
LGM-5-24						24
LGM-5-36						36
LGM-5-48						48
LGM-5-60						60
LGM-5-72						72

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OPTICAL FIBERS are constructed of a glass core surrounded by a glass cladding of a lower index of refraction and transmit light by the phenomenon of total internal reflection. Rays entering one end of the fiber are carried by multiple internal reflections to the opposite end. A bundle of randomly arranged fibers will transmit light only. A

"coherent" fiber bundle, i.e. one in which both ends are arranged in an identical pattern, will transmit an optical image by breaking it up into thousands of separate components, one for each fiber, and conducting them independently from one end of the bundle to the other.

FLEXIBLE FIBERSCOPES

A flexible Fiberscope consists of a "coherent" fiber bundle containing thousands of optical fibers cemented only at the ends and free to flex in between. To obtain both high image resolution and freedom from distortion, American Optical Company utilizes "multifibers" in the construction of its Fiberscopes. Multifibers consist of a number of optically distinct coated fibers fused into a single strand. They have essentially the same mechanical properties as single fibers of the same dimensions. Standard multifibers consist of a square array of 36 fiber elements, each 10 microns in diameter.

The photograph at the right shows the image of a standard resolving power target transmitted through a 6-foot long FS-162 Fiberscope. It illustrates the typical resolution of 45 line pairs/mm for standard AO Fiberscopes.

Fiberscopes can be used to inspect hard-to-reach



locations such as the interior surfaces of piping, tanks and machinery. They can also be used in conjunction with still, motion picture and television cameras for recording and monitoring remote events or operations.

CUSTOM FIBERSCOPES

In addition to its standard Fiberscope models the American Optical Company can supply custom Fiberscopes on a special order basis. These include: Fiberscopes with various cross sectional shapes and sizes; "branched" Fiberscopes, permitting transmission of information from two or more locations to a single frame of film; Fiberscopes having varying degrees of flexibility along the length of the instru-

ment; and Fiberscopes molded to shape to permit installation in existing structures. Instruments have been supplied in diameters ranging from 1/8 inch to 2 inches and in lengths ranging from 1 foot to 100 feet.

We will be pleased to evaluate the feasibility and cost of custom applications upon request and specifications.



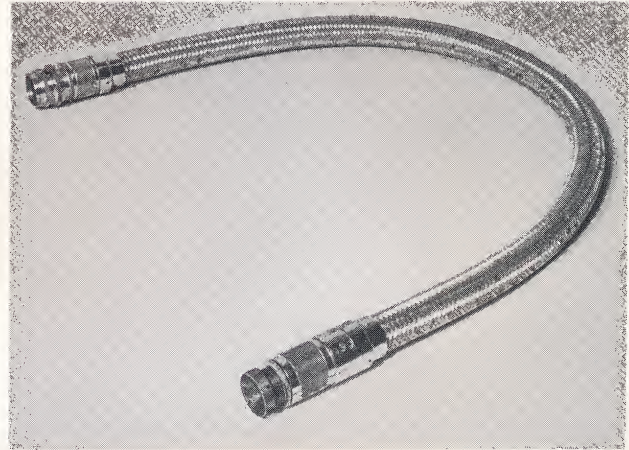
MODEL FS-162. FIBERSCOPE

The FS-162 Fiberscope is useful as an inspection device and as an image transfer device in photo-optical systems. Specific applications have included: photographic instrumentation in the Atlas and Saturn missiles, jet engine test stand instrumentation, the monitoring of electron beam welding, stereo photo-interpretation apparatus, rocket fuel core inspection and the observation of surgical and operating room procedures.

The image-transmitting fiber bundle of the FS-162 Fiberscope is sheathed in a rugged, but flexible, hydraulic hose having a Teflon liner covered with stainless steel braid. End fittings are made of stainless steel and carry a 1"-32 thread.

One of the end fittings contains a rotation device actuated by a tangent screw which permits one end of the fiber bundle to be rotated through an angle of $\pm 150^\circ$ with respect to the other end for purposes of adjusting the orientation of the fiber bundle format relative to the field of view.

The standard unit includes the Fiberscope, two Type FS-16-CMF adapters, two dust caps and a



carrying case. The FS-16-CMF adapter has a standard "C" mount thread that will accept 16 mm Ciné camera objectives or the accessory 10X eyepiece. The Type FS-16-CMA adapter is especially designed to couple to the Type FS-1650 unit magnification relay lens for use with an auxiliary 16mm Ciné or Vidicon camera.

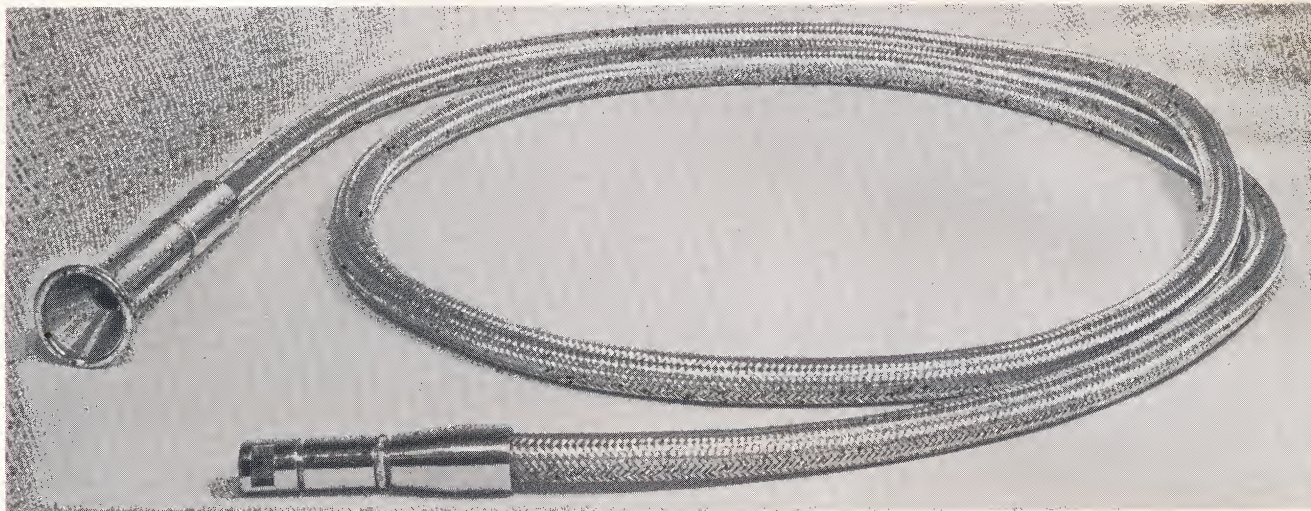
FS-162 SPECIFICATIONS

Image Format	8 x 10 mm
Fiber cross section	60 microns (.0024")
Fiber diameter	10 microns
(typical)	45 line pairs/mm
	$\pm .0024"$ max. deviation
Image	1% maximum
Fibers	675,000 (nominal)
Viewing Angle	60° included
	1.3 inch maximum
	2½ inch minimum (inside)

CAT. NO.	PARTS AND ACCESSORIES
FS-162-24	2 ft. Fiberscope
FS-162-36	3 ft. Fiberscope
FS-162-48	4 ft. Fiberscope
FS-162-60	5 ft. Fiberscope
FS-162-72	6 ft. Fiberscope
FS-16-EP	10X Eyepiece
FS-1610	25 mm Wollensak objective lens
FS-1620	50 mm Wollensak objective lens
FS-1650	AO-3M Wollensak relay lens (1:1)
FS-16-CMF	Standard "C" mount adaptor
FS-16-CMA	Adjustable "C" mount adapter
FS-16-RA	Right angle prism for FS-1610 lens
FS-16-CC	Carrying case



MODEL FS-81 FIBERSCOPE



The Model FS-81 Fiberscope is used as an inspection tool and as an image transfer device for photo-optical systems in applications where the FS-162 Fiberscope cannot be used due to its larger diameter.

The FS-81 Fiberscope consists of a 5 x 5 mm square "coherent" image-transmitting fiber bundle with 10 micron elements sheathed in a rugged but flexible hydraulic hose 17/32 inch in diameter. The sheath consists of a Monel metal bellows covered

with stainless steel braid. The end fittings are made of stainless steel and are threaded for attachment of the optical accessories. The instrument will pass into a 5/8 inch diameter hole.

The unit includes the basic Fiberscope, a 10X eyepiece, a 10 mm focal length objective lens in a focusing mount, a 90° prism for right-angle viewing and a carrying case.

FS-81 SPECIFICATIONS

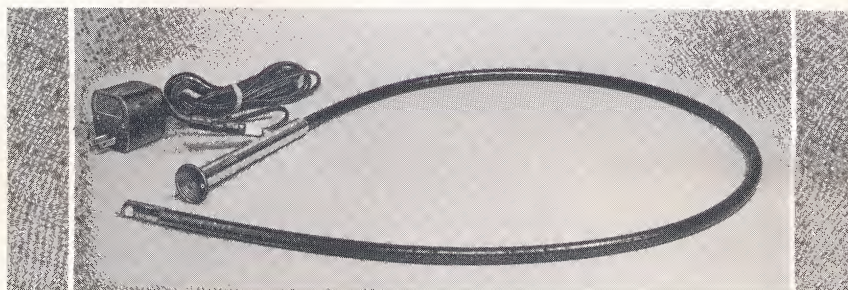
Image Format	5 x 5 mm
Multifiber cross section	60 microns (.0024")
Individual fiber diameter	10 microns
Resolution (typical)	45 line pairs/mm
Coherency	±.0024" maximum deviation
Fiber breakage	1% maximum
Number of fibers	210,000 (nominal)
Fiber Acceptance Angle	60° included
Distal O.D.	0.610 inch maximum
Radius of Bend	1¼ inch minimum (inside)

CAT. NO.	PARTS AND ACCESSORIES
FS-81-24	2 foot Fiberscope
FS-81-36	3 foot Fiberscope
FS-81-48	4 foot Fiberscope
FS-81-60	5 foot Fiberscope
FS-81-72	6 foot Fiberscope
FS-81-EP	10X Eyepiece
FS-81-OL	10 mm objective lens
FS-81-RA	Right angle viewing prism
FS-81-CC	Carrying case

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MODEL FS-41 FIBERSCOPE



The FS-41 Fiberscope is designed specifically for visual inspection of remote and otherwise visually inaccessible areas inside tubes, tanks, reactors or machinery.

It contains both a "coherent" image-transmitting fiber bundle and an integral fiber optic lighting system to illuminate the field of view. It is fitted with a focussing eyepiece and an adjustable focus objective lens. It can be used for viewing either in the forward direction or at right angles by means of the 90° adaptor supplied. The instrument will pass into a 1/2 inch hole.

In the Model FS-41 Fiberscope, light is conducted to the field of view from a small tungsten lamp located near the eyepiece by means of three fiber optic Light Guides housed within the protective sheath along with the "coherent" fiber bundle. The "cold" light provided by this arrangement is ideally suited for inspection of areas in which electrical leads might prove hazardous. A transformer and three spare lamps are supplied with the Fiberscope.

If an even more remote light source is required the small tungsten lamp may be replaced by an extension Light Guide (FSLG) coupled to the K-150 Illuminator.

FS-41 SPECIFICATIONS

Image Format	3 mm diameter
Multifiber cross section	60 microns (.0024")
Individual fiber diameter	10 microns
Resolution (typical)	45 line pairs/mm
Coherency	±.0024" maximum deviation
Fiber breakage	2% maximum
No. of fibers	63,000 (nominal)
Fiber Acceptance Angle	60° included
Distal O.D.	.485 inch
Radius of Bend	1 inch minimum (inside)

CAT. NO.	PARTS AND ACCESSORIES
FS-41-24	2 foot Fiberscope
FS-41-36	3 foot Fiberscope
FS-41-48	4 foot Fiberscope
FS-41-60	5 foot Fiberscope
FS-41-72	6 foot Fiberscope
FS-41-RA	Right angle viewing mirror
FS-41-T	Transformer
FS-41-L	Lamp
FS-41-CC	Carrying case
FSLG-36	3 foot Light Guide with coupling attachment
FSLG-48	4 foot Light Guide with coupling attachment
FSLG-60	5 foot Light Guide with coupling attachment
FSLG-72	6 foot Light Guide with coupling attachment
K-150	Illuminator